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LEARNING FROM THE ENEMY – OFFENSIVELY, WHAT IEDS SHOULD TEACH THE U.S.

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ABSTRACT

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The United States has invested a great deal of money and effort to defeat Improvised Explosive Devices (IEDs) and attack IED networks. However, relatively little research exists that seeks to learn applicable lessons from insurgent's tremendous offensive success with these crude explosive hazards. This paper aims to identify these offensive lessons learned and explore what methods and resources the U.S. should develop to fully exploit the power of explosive hazards on the Full Spectrum battlefield. It will accomplish this by reviewing current U.S. landmine policy and existing U.S. landmine capabilities. It will review SPIDER and SCORPION, 'networked munitions' that are the new U.S. landmine replacements. Finally, the paper will suggest necessary improvements to these networked munitions and their supporting doctrine with the goal of allowing the U.S. to fully exploit the lessons that IEDs can teach about the relevancy of explosive hazards on the Full Spectrum battlefield.

LEARNING FROM THE ENEMY – OFFENSIVELY, WHAT IEDS SHOULD TEACH THE U.S.

After the Cold War ended, most of the western world basically abandoned land mine warfare.[1] [2] Unfortunately however, their enemies did not. Much talent and treasure has been invested by the U.S. to learn how to defeat Improvised Explosive Devices (IEDs) and attack IED networks. However, relatively little research exists that seeks to learn applicable lessons from the insurgent's tremendous offensive success with devices that are little more than homemade mines.

One might dismiss the value of this inquiry by arguing that improvised mines/IEDs are a weaker-force weapon, effectively used only by guerrilla forces conducting asymmetric warfare. One might also posit that IEDs are effective only because the insurgents got lucky and found an exploitable seam in U.S. strengths.[3] These arguments are injurious if they prevent us from critically examining the fundamental underpinnings that led to the dominant role that improvised mines/IEDs played in Iraq and are now playing in Afghanistan. In short, the United States would be wise to learn from its enemies.

What we can learn

To win, you must be able to kill.

To date, 2,531 U.S. service members have died in Iraq and Afghanistan due to mines and IEDs and over 23,650 have been injured.[4] Putting these numbers into perspective, over 61% of the total hostile deaths and over 75% of the hostile casualties in these two wars have been caused by improvised mines and IEDs. The effects that these casualties had on the course of these conflicts should not be understated.[5] During the height of the Iraq insurgency in 2007 the casualties inflicted by these

devices, more so than any other single fact, were the reason the U.S. military was seen as loosing the fight.[6] In Afghanistan, thought comparatively slow to discover the advantages of IEDs, the Taliban have now turned them into their primary weapon.[7]

The simple reason for this is that IEDs work.[8] In the study of war and the admirable desire to turn it into a 'science', one can often overlook the simple yet profound fact that, in the end, war is about killing. The base ability to attrit enemy forces – or to kill – remains a fundamental variable that equates to power on the battlefield. In the IED fight, some have posited various ideas in regard to the strategic and operational advantages that insurgents gain from IEDs.[9] These are useful reflections, but it is critical to always remember that these higher order battlefield effects stem from one thing - the enemy's central ability to kill its adversaries.

Lesson Learned #1: IEDs are an effective means to kill one's enemy.

Better yet, kill without being killed.

During the summer of 2003, in the early days of the Coalition Force operations in Iraq, the various insurgent-terrorist-criminal groups started to coagulate after the chaos of the initial invasion dissipated. Throughout this period they initiated their attempts to attack the Coalition Forces, gain power and apply their will using the weapons they had knowledge of and access to - light machine guns, rocket propelled grenades and small mortars.[10] However, to be effective, small arms attacks required that insurgents engage at relatively close ranges with few forces. At greater ranges their weapons were generally ineffective and if they attempted to mass significant forces to achieve volume of fire, their activities were often prematurely detected. The result of close quarter battle was often the death of the insurgents, particularly after the U.S. fielded uparmored HMMWVs and adequately deployed machine guns on its patrols/convoys.

To counter overwhelming U.S. firepower, some insurgents cunningly evolved their tactics and employed a weapon that allowed them to avoid a close quarter battle – land mines and improvised landmines, which we label IEDs. Insurgents in Iraq did not invent the IED; however they've employed it with great effectiveness.[11] Using military grade munitions (primarily artillery shells and mortar rounds) that were widely distributed throughout Iraq, the insurgents had a readily-available base explosive component for their improvised landmines. The next ingredients that completed the devices were either basic direct command operated firing circuits (electric wire and electric blasting caps), or crudely though ingeniously devised remote control firing devices such as washing machine timers or remote car door locking devices connected to a battery and an electric blasting cap.

These early, basic IEDs afforded the enemy sufficient standoff to avoid U.S. direct fire. Standoff also allowed the insurgents to protect their most valuable resource – their anonymity. Anonymity allowed insurgents to live undetected among their enemies, gaining information and choosing the time and place for battle.[12] As U.S. forces devised countermeasures, the enemy subsequently increased IED sophistication in a cycle of action-reaction-counteraction. Over the next six years, the base explosive expanded to include home-made explosives and improvised or industrially produced shape charges, platter charges and explosively formed penetrators (EFPs). Simultaneously, triggering initiation systems evolved. Victim-operated initiators such as pressure plates, crush wire and passive infrared triggers were employed. Remote control command initiated triggers also became more sophisticated using cordless

telephone phone base stations, walkie-talkies, and cell phones.[13] Finally, it is important to note that insurgents in Iraq have also employed conventional military landmines.[14]

However, regardless of technical manifestation, IEDs were always devised to reduce the risk of insurgent death or disclosure by giving them a standoff capability. As an Al-Qaeda training manual states, "Explosives are believed to be the safest weapon for the Mujahideen. [Using explosives] allows them to get away from enemy personnel and to avoid being [caught]."[15] Looking at the development of the IED through the lens of Western military thought, IEDs are akin to modern robotic devices or Unmanned Aerial Vehicles (UAVs) – they tirelessly do dangerous work that is too risky for Soldiers or pilots to perform.

Lesson Learned #2: IEDs greatly reduce risk.

Kill the most with the least.

Though the exact strength of the ever shifting insurgency in Iraq is difficult to quantify, at its height in the summer of 2007, it was conservatively estimated at 70,000.[16] During that same period, Coalition Forces and Iraqi Security Forces numbered approximately 539,979.[17] This equates to the enemy *attacking* a force 7 ½ times its own strength. In Afghanistan, the insurgency is currently believed to have a strength of 25,000.[18] At present, U.S., NATO-International Security Forces, and Afghanistan Security Forces number approximately 277,150.[19] This yields a ratio of 1 enemy fighter for every 11 U.S./NATO/ASF Soldiers. IEDs are the main reason that these greatly outnumbered insurgent forces have been effective.

With respect to monetary costs, it is estimated that the US has spent, through FY 10, a total of $748 billion in Iraq and $299 billion in Afghanistan, or over $1 trillion dollars on the wars.[20] Focusing in on the IED fight, the Joint IED Defeat Organization (JIEDDO)

has itself spent over $16 billion dollars.[21] Breaking these massive numbers down to a figure which one can perhaps better grasp, a single MRAP can cost up to $800,000.[22] Therefore, a three MRAP patrol is valued at over $2.4 million. As to the people in those MRAPs, *Newsweek* reports a single Solder in Afghanistan costs $1M annually.[23] To counterpoint these astronomical costs, for the insurgents a single 155mm artillery shell, the base explosive of many IEDs, was likely freely looted from the innumerable Iraqi Army caches. Wire to construct a simple command-initiated trigger for the artillery shell was usually stripped from the armature of an old electric motor and probably costs next to nothing, while the electric blasting cap and a battery to power it likely costs only a few dollars. Even deadly explosively formed penetrators might cost only $30 to make and an advanced passive infrared trigger armed via a cell phone perhaps costs a few hundred dollars.[24] The individuals required to emplace these IEDs are generally paid from $25 - $300 per IED.[25]

IED networks, working in a loosely coupled web and driven by a myriad of motivations, achieved – in the end – the effect of efficiently concentrating their combined combat power against Coalition and Iraqi Security Forces. This forced a tremendously costly reaction in terms of manpower, money and resources from the United States. Using IEDs as a combat multiplier a few, operating with little, tremendously affected many, causing them to commit much.

Lesson Learned #3: IEDs provide superb Economy of Force.

Ideally - achieve your goals without having to actually kill.

On ancient Mesopotamian plains modern insurgents realized one of the timeless pinnacles of generalship by subduing their enemy's movement without having to directly fight. They did this by employing IEDs to drastically limit the movement of Coalition and

Iraqi Security Forces.[26] Based on the IED threat, Coalition Forces significantly restricted the amount of movement they conducted outside their large, heavily armed Forward Operating Bases. IEDs and traditional landmines, used both as traditional tactical blocking obstacles and close in protective obstacles, thwarted 'Clear' operations and provided sanctuary to enemy forces. IED attacks along patrol routes and Main Supply Routes (MSRs) greatly affected the ability of Coalition Forces to 'Hold' areas and even further weakened their ability to sustain fragile 'Build' operations.

Moreover, to protect themselves from IED blasts, Coalition Forces adopted aggressive driving postures to thwart IED triggermen and isolated themselves in large, lumbering MRAP vehicles from the people they came to liberate. Their powerful IED jammers scrambled any sense of normalcy by wreaking havoc with the daily communications of Iraqi citizens. Any sense of normalcy was further eroded by the removal or 'sanitation' of any structure (guardrails, light posts or curbs) in which insurgents could hide an elevated, and thus more lethal, IED.[27]

All of these actions worked in polar opposite to the fundamentals of counterinsurgency, or COIN, strategy: "The first rule for COIN operations is to establish presence in the AO [Area of Operations]… Being on the ground establishes links with the local people. They begin to see Soldiers and Marines as real people they can trust and do business with, rather than as aliens who descended from armored boxes."[28]

In this regard, IEDs allowed the insurgent forces to significantly shape the battlefield to their advantage. IEDs protected insurgent safe havens and functioned as highly effective obstacles to movement and maneuver. As such, they performed the role that the U.S. Army traditionally prescribes to tactical landmines. The enemy's use

of IEDs in a COIN operation also negatively affected both the operational and strategic situation to a significant degree by disrupting Coalition forces' contact with the people.

Lesson Learned #4: IEDs effectively constrain enemy movement and in COIN operations inhibit interaction with the main objective – the populace.

Summary of Insurgent's Lessons Learned:

- Lesson Learned #1: IEDs are an effective means to kill one's enemy.
- Lesson Learned #2: IEDs greatly reduce risk.
- Lesson Learned #3: IEDs provide superb Economy of Force.
- Lesson Learned #4: IEDs effectively constrain enemy movement and in COIN operations inhibit interaction with the main objective – the populace.

Applicability of these Lessons Learned to the U.S.

LL- #1. Does the U.S. seek additional effective means to kill the enemy? Certainly. However, unlike insurgents who oftentimes disregard the indiscriminate nature of IEDs, U.S. forces must target precisely. In the ongoing counterinsurgency fights in Iraq and Afghanistan, if a new capability existed and it allowed U.S. forces to distinguish between an insurgent and an innocent civilian, then this additional capability would be greatly valued.

LL - #2. Does the U.S. seek to greatly reduce risk? Absolutely. Every commander strives to accomplish their mission while minimizing casualties. Each mission that goes 'outside the wire' is carefully gauged to ensure that risk is acceptable given the military necessity of the mission. As the recent increase in the number and type of ground robots and UAVs deployed on the battlefield indicates, mechanisms that maximize mission accomplishment while minimizing risk of harm to Soldiers are in great demand.

LL - #3. Is the United States interested in ways to better prosecute an Economy of Force mission? Without a doubt. There are simply too many missions for too few

troops. With many Soldiers on their third or fourth year-long combat deployment, the strain of multiple deployments is certainly taking its toll on the All Volunteer Force. Commanders would greatly covet any way that allowed them to do more with less. Also, given the current unsustainable Federal deficits, cost effective methods that allowed the U.S. to successfully control the ground with fewer expensive Soldiers (remember that a Soldier deployed to Afghanistan costs ~$1M/year) would be readily adopted.

LL - #4. Finally, would the U.S. want to improve its ability to constrain the enemy's freedom of movement and better shape the battlefield? Indeed. As the 2007 OPERATION FARDH AL-QANOON (Baghdad Security Plan) demonstrated, limiting insurgent movement substantially reduced violence and greatly aided in the overall goal of protecting the population.[29] During this operation, massive concrete barriers were erected throughout Baghdad, and later in other Iraqi cities such as Samarra, to successfully limit enemy movement. Commanders would readily embrace any mechanism that was cheaper, more effective and less ponderous than acquiring, transporting, and emplacing 20-ton concrete blocks.

Examining the applicability of these thoughts to Iraq, commanders certainly want to kill the insurgents who are emplacing IEDs along the theater's Main Supply Route (MSR TAMPA). Killing even low-level IED-emplacers would doubtlessly reduce the risk to U.S. and Iraqi forces, free up forces for other counterinsurgency missions and increase U.S./Iraqi freedom of movement. An ability to kill IED-emplacers in a given area would likely deter them from using that particular 'IED Kill Zone', further diminishing their effectiveness. In Afghanistan, killing insurgents who conduct IED attacks or hilltop ambushes would have similar battlefield advantages to

U.S./NATO/Afghan forces. However, to implement these Lessons Learned and gain their benefit, the U.S. must have both the correct doctrine (methods) and a viable mine (resources). Unfortunately, they currently possess neither.

Much more than a 'nuisance' – current U.S. Mine Warfare Doctrine

The main U.S. doctrinal reference for mine warfare is FM 3-34.210, *Explosive Hazards Operations.*[30] In it, the U.S. Military classifies minefields (as opposed to individual mine munitions) into five types, depending on their purpose. They are Protective, Point, Interdiction, Phoney and Tactical.[31]

Protective minefields are employed to assist a unit in its local, close-in protection and can be either temporary (called Hasty Protective) or more long-term (called Deliberate Protective). Point minefields are intended to disorganize enemy forces and hinder their use of key areas while Interdiction minefields are placed actually on the enemy or in its rear area to kill or disrupt Lines of Communication (LOC) or Command and Control (C2).[32] Phoney minefields are munitions-free areas made to look like actual minefields with the purpose of deceiving the enemy.

Tactical minefields are employed to directly attack enemy maneuver, giving an advantage to defending forces. The minefield location, depth, width, density and composition are varied to achieve four specific effects: Disrupt, Fix, Turn, and Block.[33] Offensively, tactical obstacles can be used to protect flanks, isolate objective areas, deny counterattack routes or disrupt retrograde capabilities. Another type of Tactical minefield is the Nuisance minefield. Nuisance minefields hinder the use of an area or route and are intended to impose caution on enemy forces by disrupting, delaying or imparting doubt. FM 3-34.210 *Explosive Hazards Operations* explicitly states: "Nuisance minefields can be used similarly to booby traps and IEDs."[34] Numerous other

IED references in this manual are all related to defeating IEDs, not emulating them. This is noteworthy because as their battlefield performance proves, IEDs are much more than a 'nuisance'.

Interestingly, the Army's main doctrinal reference for *combating* IEDs, FM 3-90.119, *Combined Army Improvised Explosive Devise Defeat Operations*, gets it right. This defensive manual accurately characterizes IEDs as obstacles to maneuver AND as close contact weapons.[35] Thus, while the U.S. has properly understood – in the defensive sense – the effects the enemy is achieving with IEDs, they have failed to fully appreciate – offensively – that their own mines can be both an obstacle and an effective means to close with and destroy the enemy.

Perhaps this mischaracterization of the battlefield prowess of explosive hazards can, in part, be traced to how mine effects were replicated and adjudicated over the past 20 years at the Army's Combat Training Centers. In the quest to force the direct fire fight, obstacle effects were greatly minimized, institutionalizing bad lessons in regard to both the employment of U.S. mines and the lethality of explosive devices. Extremely lethal explosively formed projectile IEDs were afforded great respect in Iraq even though they were never employed in great numbers. A single U.S. Ground VOLCANO minelayer contains 800 of the most technically advanced anti-armor explosive devices ever manufactured.[36] Yet during pre-OIF/OEF Combat Training Center rotations the VOLCANO systems were significantly constrained and their effects poorly replicated. This downplaying of the effects of modern landmines fostered a lack of appreciation for explosive devices in many Army leaders, faulty notions that were literally blown away by the enemy's successful employment of IEDs.

International Treaties Governing Mine Warfare.

Doctrinally equating IEDs to Nuisance minefields seems rather myopic given IED's demonstrated battlefield effectiveness. In addition to the above mentioned deficiencies in providing realistic training against explosive hazards, perhaps this distorted vision can also be attributed to the disdain with which traditional forms of land mines are now held by the western world. These views are best conveyed in two documents: 1) *1996 Amendments to Protocol II of the 1980 Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects* (knows as the Convention on Certain Conventional Weapons – or CCW) and 2) *Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on Their Destruction* (known as the Ottawa Treaty).

The base CCW treaty, ratified by the U.S. in April of 1982, was the first treaty to attempt to regulate land mines.[37] It contained three Protocols, each of which regulated the use of a particular type of conventional weapon thought to pose special risks of indiscriminate effects or unnecessary suffering. The Amended Protocol II to the CCW treaty, ratified by the U.S. in May of 1999, addresses the use of mines and booby traps. Among other things, it establishes the principle that non-self-destructing anti-personnel landmines may be used only within perimeter marked areas, protected and monitored to ensure the effective exclusion of civilians; remotely-delivered mines must self-destruct within 30 days at 90% reliability and self-deactivate within 120 days with an overall reliability of 99.9%.[38]

The other main document, the Ottawa Treaty, has not been signed by the United States. It was, however, signed by 156 other countries, including all of the other NATO

countries, Japan, Australia, as well as Iraq and Afghanistan.[39] This treaty bans the use of all anti-personnel (AP) landmines, making no distinction between persistent AP mines or non-persistent (i.e. those that self-destruct or self-deactivate) AP mines.[40] Rather, the treaty's prohibitions are based on how the mine is triggered. The Ottawa Treaty defines an AP mine as, "a mine designed to be exploded by the presence, proximity or contact of a person and that will incapacitate, injure or kill one or more persons."[41] Having a man-in-the-loop who can confirm that the target is a combatant is the only method to trigger AP mines deemed satisfactory to the international community.[42]

On 24 November 2009, before the start of the Second Review Conference of the Ottawa Treaty in Cartagena, Colombia, President Obama's administration announced that it was keeping in place the President Bush-era landmine policy and would not sign the Ottawa Treaty. Eventually, however, the State Department clarified the government's position by stating that U.S. land mine policy was still under review.[43]

U.S. Landmine Policy. [44]

Current landmine policy states that the U.S. will:

- Eliminate all persistent landmines from its arsenal.
- Continue to develop non-persistent (self-destructing/self-deactivating) landmines that will not pose a humanitarian threat after use in battle.
- Continue to research and develop enhancements to the current self-destructing/self-deactivating landmine technology in order to develop and preserve military capabilities that address the United States transformational goals.
- Seek a worldwide ban on the sale or export of all persistent landmines.
- Get rid of its non-detectable mines within one year.
- Only employ persistent anti-vehicle mines outside of Korea between now and 2010, if needed, when authorized by the President.
- Not use any persistent landmines – neither anti-personnel nor anti-vehicle – anywhere after 2010.
- Begin the destruction within two years of those persistent landmines not needed for the protection of Korea..

- Seek a 50 percent increase in the U.S. Department of State's portion of the U.S. Humanitarian Mine Action Program over Fiscal Year 2003 baseline levels to $70 million a year.

Current Landmine Options Available to Commanders

Future U.S. mine policy will likely adopt a complete ban on all AP landmines. Regardless of these possible policy restrictions, there are few options currently available to U.S. field commanders that would allow them to exploit the same advantages that improvised mines/IED have produced for the enemy. With the U.S. no longer using persistent landmines, the only fielded mines available to commanders are scatterable mines that self-destruct/self-deactivate and the one 'smart' munition system that has been fielded.

Reviewing these current mine options in more detail, the GATOR mine system is comprised of both anti-tank (AT) and AP mines and is delivered via dispensers on fixed wing aircraft. The VOLCANO mine system is employed via helicopter mounted dispensers or ground mounted dispensers. It has two versions, one with a mix of AT and AP mines, and one comprised only of AT mines. There are two versions of scatterable mines that are fired from U.S. artillery. The Area Denial Artillery Munitions (ADAM) is comprised of AP mines while the Remote Anti-Armor Mines (RAAM), as the name suggests, is comprised of AT mines. The final scatterable system is the Modular Pack Mine System (MOPMS). It is comprised of a mix of AT and AP mines. It is distinct from all of the other systems in that it is capable of command detonating its mines. The other scatterable mine systems only self-destruct after a set period of time elapses.[45]

The one ‘smart’ munition that is currently fielded is the M93 Hornet Wide Area Munition. The Hornet is a hand emplaced, AT munition that uses a top attack smart weapon to engage targets out to 100 meters.[46]

To date, however, U.S. forces have not used any of these old systems in the wars in Iraq or Afghanistan.[47] [48] The self-evident reason for this is that commanders have decided that these old mines do not adequately address their tactical problems. Simply put, the U.S. has entered into a de facto ban on landmines as none of the current systems are sufficient to aid in the prosecution of the ongoing conflicts.

Many recent discussions have centered on the U.S. military’s hesitancy to restructure and rearm itself to fight its current wars and instead stay stubbornly focused on future major combat operations.[49] Recognizing this issue, the new landmine replacements coming into operation in the near-future should be useful to commanders across the full spectrum of operations.

Near-Future Alternatives

Realistically, it is now problematic to saddle any new device with the moniker of ‘mine’. Regardless of how technologically advanced the device is, calling something a ‘mine’ now carries so many negative connotations that, in all eventuality, no commander would risk the Public Affairs and Information Operations disadvantages of employing it. Understanding this, the U.S. is now carefully labeling its latest devices as ‘munitions’. It has even gone so far as to rename the venerable Claymore mine as the M18A1 Claymore *munition*.[50] These are wise decisions as they will make the next generation of munitions more acceptable. However, before these new munitions can be acceptable to the American people, they first need to provide commanders an advantage over the enemy and thus be applicable. This applicability comes from both

the capabilities of the new munitions and the soundness of doctrine used to employ them.

Currently the U.S. Army has two new systems, characterized as 'networked' munitions, entering the final stages of development or entering low rate initial production. These ground emplaced networked munitions are designed to be recoverable, reusable and scalable and both have lethal and less-than-lethal capabilities.[51]

SPIDER is the AP system. In a 2001 National Academy of Science study of alternative technologies to replace AP landmines, SPIDER, then know as the Track I Non Self-Destruct Alternative (NSD-A), was identified as the most promising alternative to the old persistent AP mines.[52] SPIDER notifies an operator manning a Remote Control Station (RCS) when its trip wire sensors have been triggered. The operator then decides whether or not to fire its munitions or take other action.[53] One RCS can control a number (or 'network') of individual SPIDERs. This man-in-the-loop manual engagement capability makes it compliant with the Ottawa Treaty as there is no autonomous triggering (also referred to as 'target activation') of the modular munitions.[54] SPIDER is designed to serve primarily as a protective obstacle and it allows the U.S. Army to meet National Landmine Policy by developing and fielding a landmine alternative prior to 2010.[55]

SCORPION is the AT system. Like SPIDER, SCORPION is networked to a central Control Station which can activate or deactivate individual munitions. Using acoustic, seismic and radar sensors, SCORPION fires a top attack munition that can destroy heavily armored vehicles.[56] However, unlike SPIDER, SCORPION can be set

for either autonomous or manual engagements.[57] SCORPION's primary role is to function as a tactical obstacle, denying the enemy freedom of maneuver.[58]

Close, but not enough

SPIDER and SCORPION are indeed a tremendous leap forward from the old, inefficient days of using battalions of Soldiers to bury persistent landmines in massive rows across the battlefield. When one has the required ground access to the battlefield, these new networked munitions are also vastly superior to slinging scatterable mines into precisely unknown positions with no ability to disarm them other than to wait until they self-destruct. SPIDER should work superbly as a protective obstacle against a conventional foe. SCORPION undoubtedly will function brilliantly as a reinforcing tactical obstacle. If the U.S. was currently fighting pitched battles against a heavily armored foe, these new systems would certainly prove invaluable.

However, as currently configured, SCORPION, and to a lesser extent SPIDER, will likely have limited applicability in the ongoing counterinsurgency wars in Iraq and Afghanistan. The reason for this is that neither SPIDER's trip wire sensors nor SCORPION's acoustic/seismic sensors can adequately convey 'hostile intent' to a Soldier manning the Remote Control Station. A trip wire simply cannot, on its own, distinguish an IED emplacer from a goat herder. An acoustic/seismic sensor cannot distinguish a Kia Bongo truck with a load of watermelons from a Kia Bongo truck loaded with a 120mm mortar. Without this base ability to positively determine whether or not the 'target' is friendly, enemy or an innocent civilian, the value of these advanced systems in the current wars is limited.

Observation

Observation is the only feasible way to divine hostile intent on the cluttered and confusing counterinsurgency battlefield. This fact is born out by the insatiable battlefield demand for any and all electro-optical devices, from cameras on blimps, towers and walls to the various manned and unmanned aerial observation platforms such as CONSTANT HAWK, AIRSCAN and SHADOW.

This tremendous demand for systems with observation capability is contrasted with the less than overwhelming demand for systems that don't, like the current generation of Unattended Ground Sensors (UGS). USG contain only seismic/acoustic sensors and though they were rushed to theater, most languish unused in CONEXs.[59] Fortunately, the Army has realized these shortcomings. The next generation of sensors, called Tactical-Unattended Ground Sensors (T-UGS) and Urban-Unattended Ground Sensors (U-UGS), which are all part of the Brigade Combat Team Modernization effort, do contain this essential optical component.[60]

Doctrinally, all obstacles, both protective and tactical, should be under constant observation.[61] Obstacles should also be covered by direct fire and indirect fire. This is true whether or not the obstacle is explosive (e.g. mines) or physical (e.g. T-wall barriers). For protective obstacles, integration of SPIDER with the Army's Base Expeditionary Targeting and Surveillance System-Combined (BETSS-C) seems obvious. BETSS-C is an umbrella acquisition program, designed to incorporate numerous platforms to provide surveillance capabilities for force protection at bases and outposts.[62] Similar sensor integration initiatives, such as SCORPION with T-UGS, look obvious as well. It would be ideal, however, if networked munitions had an organic observation capability.

Thankfully, it appears that the Army has acknowledged this as the growth path (Increment II) of SCORPION and SPIDER should possess an optical day and night imager.[63] Doing so, however, will entail necessary trade-offs of increased weight, cost, cube size, detectability and power requirements.[64]

To complement the COIN capabilities of the optical sensors, a modular audible warning module should also be developed for SPIDER. This module would consist of a loud-speaker and recordable audio player. Once triggered by the sensors or the RCS operator it would broadcast and repeat a loud voice message, in the local dialect, warning of the dangers of the networked munition field. A non-lethal florescent/infrared dye pack grenade should also be developed. This would aid in identifying for subsequent questioning those individuals whose hostile intent is unclear.

Fully networking Networked Munitions

Each sensor system, whether tied to a munition of not, objectively should fully integrate with the overarching Army Battle Command System (ABCS). ABCS integrates the Army's various Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance systems and forms the digital backbone of the Common Operating Picture (COP). The COP affords commanders situational awareness by giving them an integrated view of friendly forces, enemy actions and the terrain. Sensor outputs from network munitions should be included in this integrated view of the battlefield provided that safeguards can be developed that protect the integrity of the overall network.

With a visual observation capability and the ability to fully integrate into the Army's Command and Control network, SPIDER and SCORPION will give the U.S. the

means to adopt the lessons taught by IEDs. The only thing then lacking is the doctrinal *ways*.

Still not enough

The *ways* or methods of using SPIDER and SCORPION, as codified in doctrine, must recognize that these systems are capable of being much more than protective or tactical obstacles. As IEDs horrifically demonstrated, SPIDER and SCORPION are also extremely valuable as close contact weapons. The doctrine on how to employ these new networked munitions, as listed in the current version of FM 3-34.210 *Explosive Hazards Operations*, is therefore incomplete since it fails to address this powerful additional role.[65]

This is both a fundamental and an incremental change. Old, persistent, victim-operated AT landmines, like M15s, were not viewed as close contact weapons. However, Claymore *mines/munitions* have always been viewed this way. Doctrine writers must ensure that they categorize SPIDER and SCORPION as BOTH traditional protective/tactical obstacles and as close contact weapons.[66] To give ground commanders the necessary understanding on how best to employ all of the capabilities of these new networked munitions, the Army must develop the requisite Tactics, Techniques and Procedures and ensure that they are codified in both Army and Joint doctrine.

A vision of the future

To illustrate how SPIDER and SCORPION might be used in a COIN scenario, the following theoretical vignette is put forward. **Note**: The capabilities described are ideal objective capabilities, not actual current capabilities.

A battalion commander in Iraq devised a scheme of operations to secure over 90 km of MSR in his Area of Operations. He had only three companies of combat power, the majority of which were employed protecting the population and training the local security forces. Engineer Route Clearance patrols 'cleared' the MSR of IEDs a few times each day, but the battalion lacked the strength to 'hold' the cleared roads and nascent Iraqi Security Forces were not yet capable enough to perform the task themselves. The battalion identified three active 'IED Hotspots' spread out along the MSR. These IED Hotspots were areas of high IED activity where enemy IED networks had both favorable terrain for IED attacks and a complaisant local population. Four Soldiers were killed in these hotspots in the previous two months.

In addition to other efforts to attack the IED networks, the battalion commander chose to use networked munitions to both directly attack IED emplacers and to deny insurgents the use of advantageous terrain. Two IED Hotspots (now called Targeted Areas of Interest - TAIs) were in rural, open desert. The third TAI was located in the center of a mid-size town.

At the urban TAI, based on the volume of civilian activity and the dense urban nature of the terrain, the battalion commander deemed it a less than ideal location for networked munitions. However, the use of SPIDER and SCORPION at the two rural TAIs allowed him to mass his other Counter-IED assets, such as airborne persistent observation systems, to fully cover this TAI.

At the two rural TAIs, the battalion emplaced 80 SPIDER AP munitions roughly 10 meters off the shoulder of the highway along both sides of the MSR. The battalion also emplaced 20 SCORPION AT munitions interspersed among the SPIDERs. Some SPIDERs were loaded with lethal grenades, others with non-lethal munitions. The non-lethal munitions consisted of a mix of flash-bang grenades, rubber pellet grenades, florescent/IR dye grenades and audible warning modules. The SCORPIONs were set for manual activation.

Once emplaced, the Remote Control Station (RCS) operator, working from a local patrol base a few kilometers away, employed the SPIDER's trip wire sensors and monitored the sensor feeds. During the next day, a goat herder wandered into the munition field. The tripwire sensors and video feeds alerted the RCS operator who triggered a flash-bang grenade followed by the audible warning module, warning the goat herder away. The goat herder went home and warned his family/tribe/village who inquired at the local police station. Trusted local police were previously briefed on the munition field and they explained that its purpose was to protect the local population and that safeguards, like the audible warning, were in place to protect the locals. The police chief asked the locals to leave the devices alone. However, one enterprising local who learned of the munition field was both a part-time criminal and a part-time insurgent. This individual decided that since

these new American devices didn't seem lethal, he might be able to make some money by snatching one and selling it to a local insurgent cell.

Around noon the following day, he stopped his car beside the road, ran out into the munition field, grabbed a SCORPION and ran back to his car with it. In the process of doing so, SPIDER trip wire sensors were triggered, but the RCS operator was unsure about hostile intent and at first only triggered a few flash-bang grenades and audible warning modules. As the RCS operator observed the SCORPION being stolen, based on a previously war-gamed scenario, he chose not to self-destruct the SCORPION or employ its self-protection AP grenades. Instead, he triggered a florescent/IR dye pack in a nearby SPIDER, deactivated the stolen SCORPION and alerted the battle captain. The dye pack grenade marked the thief with indelible florescent ink and infrared dye. The battle captain implemented a set of actions to track signals from tagging, tracking and locating devices attached to each munition, allowing the battalion to track the movement of the stolen SCORPION as it moved from location to location. This intelligence yielded insights into the local insurgent networks and, eventually, to the recovery of the SCORPION munition and capture of the thief/insurgent. The local IED cell learned of the location of this munition field and chose to halt its activity in the area. No IED emplacers were killed by this munition field, but neither were any IEDs emplaced in the TAI. The local IED cell was forced to react to the actions of Coalition Forces. In the end, the networked munition field achieved one of its intended purposes – it denied the enemy access to the TAI, thus 'holding' the cleared route.

A few days later, at the second TAI, an old taxi stopped along the highway in the middle of the night and a passenger got out. As he walked along the shoulder, he unknowingly triggered a SPIDER trip wire. Unable to positively identify hostile intent, the RCS operator didn't fire any munitions, but he alerted the battle captain to the possibility of enemy contact. The battle captain immediately checked the COP for friendly ground forces or aircraft in the area. While observing via the ground-level SPIDER-SCORPION cameras and a secondary, elevated T-UGS camera, the RCS operator witnessed the driver get out of the car, retrieve a shovel from the trunk and take it to the first man who then started to dig. The driver returned to the trunk, pulled out a 155 mm artillery shell, delivered it to the digging man and then returned to the car. Upon seeing the artillery shell, the RCS operator positively identified hostile intent (as per Rules Of Engagement worked out earlier) and triggered the two closest lethal SPIDER munitions, killing the digging insurgent. Simultaneously, he cleared fires of friendly forces with the battle captain, cleared fires of civilian automobile traffic using the seismic, acoustic, radar and optical sensors and triggered the closest SCORPION munition. The SCROPION launched a top attack warhead (necessitating the earlier clearing of airspace) which, once airborne, locked on to the IR signature of the taxi and destroyed it.

> The battle captain then launched a patrol consisting of security, EOD technicians, a Weapons Intelligence Team (WIT) and other intelligence experts to immediately exploit the scene. As the patrol approached the networked munitions field, the RCS operator turned the SPIDERs and SCORPIONs to 'SAFE', allowing the exploitation team to safely occupy the scene. The 'SAFE' status of the munition field was confirmed on the FBCB2-BFT display in the patrol leader's vehicle.

This theoretical vignette aimed to illustrate one possible scenario for employing the objective capability of networked munitions in a counterinsurgency fight. Leaders will devise many other Tactics, Techniques and Procedures once they have access to flexible, scalable, modular networked munitions backed up by innovative doctrine.

Where to from here?

IEDs have doubtlessly demonstrated that explosive hazards are an effective means to kill one's enemy, reduce risk, provide economy of force and constrain enemy movement. A few things have to happen for the U.S. to realize these same battlefield benefits with its new networked munitions.

First, the U.S. should develop and fund an imaging capability (Increment II) for both SCORPION and SPIDER. This will give these networked munitions the target discrimination capability required for the COIN battlefield.

Second, 'networked' munitions should be capable of fully integrating with other sensor systems (e.g. T-UGS) and the larger ABCS network. This ability will allow commanders to employ a mix of sensors and munitions that best fit their given tactical situation. The flexibility this integration provides will allow commanders to evolve their tactics, techniques and procedures to meet the threat, in much the same way that IEDs have evolved.

Third, Army and Joint doctrine must recognize that these new networked munitions are both tactical/protective obstacles AND direct-fire close contact weapons.

Finally, the Army must never again downplay the power of explosive hazards on the battlefield. It must remain vigilant against the enemy's use of even rudimentary explosive devices and it should endeavor to fully exploit the power of explosive hazards for its own ends.

Failure to make the necessary material and doctrinal improvements will lessen the potential usefulness of these new networked munitions on the COIN battlefield. This will result in the current status quo where insurgents use explosive hazards to great effect while the U.S. and its allies can't. This amounts to basically a one-sided arms control agreement. As has been demonstrated since the first IED detonated in Afghanistan, we blindly enter into such agreements at our own folly.

Endnotes

[1] Since Operation Desert Storm (Feb 1991), with the exception of the M18A1 Claymore mine, the U.S. military has not employed any tactical landmines. This includes conflicts in the Balkans, Somalia, Iraq and Afghanistan. Rachel Stohl, Center for Defense Information, "Lessons Learned: Using Landmines in a War with Iraq," November 25, 2002, http://www.cdi.org/terrorism/gulf-landmines-pr.cfm, (accessed 16 Dec 2009).

[2] Matthew A. Evangelista, "The Power of Precedent: Will American Practice Change the Norms of International Humanitarian Law?" Crossroads, ISSN 1825-7208, Vol 6, n.1 p 7-19. 2006.

[3] Rick Atkinson, "The Single Most Effective Weapon Against our Deployed Forces," *Washington Post*, September 30, 2007, http://www.washingtonpost.com/wp-dyn/content/article/2007/09/29/AR2007092900750.html, (accessed 17 Dec 2009).

[4] Defense Manpower Data Center, U.S. Department of Defense. "Global War on Terrorism Casualties by Reason October 7, 2001 – December 5, 2009," http://siadapp.dmdc.osd.mil/personnel/CASUALTY/gwot_reason.pdf, (accessed 16 Dec 2009).

[5] Jeff Zeleny, "Leading Democrat in Congress tells reporters, This war is lost'," *New York Times*, April 20, 2007.

[6] Atkinson, "The Single most effective weapon against our deployed forces."

[7] Christian Caryl, "America's IED Nightmare," *Foreign Policy*, December 4, 2009, http://www.foreignpolicy.com/articles/2009/12/04/americas_ied_nightmare , (accessed 6 Jan 2010).

[8] John Moulton, "Rethinking IED Strategies, From Iraq to Afghanistan," *Military Review*, July –August 2009, p 26.

[9] Ibid, p 28.

[10] Thomas E. Ricks, "*Fiasco*", (New York, Penguin Books , 2006), p 202.

[11] U.S. Department of the Army, *Combined Arms Improvised Explosive Device Defeat Operations*, FM 3-90.119, (Washington, DC: U.S. Department of the Army, 6 August 2008), p ix.

[12] Bruce R. Pirnie and Edward O'Connell, "Counterinsurgency in Iraq 2003-2006. Report for the Office of the Secretary of Defense," RAND Corp – National Defense Research Institute, 2008, p 26.

[13] Atkinson, "The Single most effective weapon against our deployed forces."

[14] Author's observations.

[15] Ben N. Venzke and Aimee Ibrahim, *Al Qaeda Tactic/Target Brief* (Alexandria: IntelCenter/Tempest Publishing, 2002), p 11.

[16] Brookings Institution, "Iraq Index," July 30, 2007, p 26.

[17] Brookings Institution, "Iraq Index," October 29, 2007, p 28, p 34.

[18] Dan Vergano, "The Science of the Afghanistan Insurgency," USA Today, 19 Dec 2009, http://www.usatoday.com/tech/science/columnist/vergano/2009-12-19-science-afghan-insurgency_N.htm , (accessed 11 Jan 2010).

[19] Brookings Institution, "Afghanistan Index," December 22, 2009, p 10-12.

[20] Congressional Research Service, "The Cost of Iraq, Afghanistan and Other Global War on Terror Operations Since 9/11 – Report for Congress," September 28, 2009, http://www.fas.org/sgp/crs/natsec/RL33110.pdf, (accessed 11 Jan 2010), p 9.

[21] JIEDDO is the Department of Defense organization whose mission is to defeat IEDs as weapons of strategic influence. United States Government Accountability Office – Report to Congressional Committees, "Actions Needed to Improve Visibility and Coordination of DOD's Counter Improvised Explosive Device Efforts," October 2009, p 1.

[22] Christian Lowe, "Marines Urge Caution on MRAP Fielding", Military.com, October 19, 2007, http://www.military.com/NewsContent/0,13319,153219,00.html, (accessed 11 Jan 2010).

[23] Jesse Ellison, "Million-Dollar Man," *Newsweek*, January 11, 2010, http://ebird.osd.mil/cgi-bin/ebird/displaydata.pl?Requested=/ebfiles/e20100104725898.html , (accessed 4 Jan 2010).

[24] Andrew Cockburn, "In Iraq, anyone can make a bomb," *Los Angeles Times*, February 16, 2007, http://www.latimes.com/news/printedition/asection/la-oe-cockburn16feb16,0,4223405.story , (accessed 14 Jan 2010).

[25] Rick Atkinson," 'There was a two year learning curve… and a lot of people died in those two years,'" *Washington Post*, October 1, 2007, http://www.washingtonpost.com/wp-dyn/content/article/2007/09/30/AR2007093001675.html, (accessed 11 Jan 2010).

[26] Pirnie, "Counterinsurgency in Iraq 2003-2006. Report for the Office of the Secretary of Defense," p 45.

[27] Author's observations.

[28] U.S. Department of the Army, *Counterinsurgency*, FM 3-24, (Washington, DC: U.S. Department of the Army, 15 December 2006), p A-4.

[29] Tim Weiner, "Walling off your Enemies: The Long View," *The New York Times*, April 29, 2007, http://www.nytimes.com/2007/04/29/weekinreview/29wein.html , (accessed 6 Jan 10).

[30] U.S. Department of the Army, *Explosive Hazards Operations*, FM 3-34.210, (Washington, DC: U.S. Department of the Army, 27 March 2007), p xiii.

[31] Ibid, p 2-8.

[32] Ibid, p 2-11.

[33] Ibid, p 2-10.

[34] Ibid, p 2-10.

[35] U.S. Department of the Army, *Combined Arms Improvised Explosive Device Defeat Operations*, p ix.

[36] U.S. Department of the Army, *Explosive Hazards Operations*, p D-15.

[37] National Academy of Science, "Alternative Technologies to Replace Antipersonnel Landmines: Executive Summary," 2001, http://books.nap.edu/openbook.php?record_id=10071&page=1 , (accessed 21 Dec 09).

[38] Office of the (U.S.) Under Secretary of Defense for Acquisition, Technology and Logistics, Treaty Compliance, "Convention on Certain Conventional Weapons/Anti-Personnel Landmines: Executive Summary," http://www.dod.mil/acq/acic/treaties/ccwapl/execsum.htm, (accessed 21 Dec 09).

[39] International Campaign to Ban Landmines, "States Parties to the 1997 Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction," http://www.icbl.org/index.php/icbl/Universal/MBT/States-Parties , (accessed 21 Dec 09).

[40] Article 1, Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, Secretary-General of the United Nations, 18 September 1997, http://www.un.org/Depts/mine/UNDocs/ban_trty.htm , (accessed 21 Dec 09).

[41] Ibid, Article 2.

[42] Thomas Kula, U.S. Landmine Policy: Continued Tension Between Military Necessity and Humanitarianism, Civilian Research Project (Carlisle Barracks, Pennsylvania, 2 April, 2004), p 10.

[43] David Alexander, "U.S. landmine policy still under review," Reuters, 25 Nov 09, http://www.reuters.com/article/idUSTRE5AN5HH20091126 , (accessed 22 Dec 09).

[44] U.S. Department of State, "U.S. Landmine Policy," 27 Feb 04, http://www.state.gov/t/pm/wra/c11735.htm , (accessed 20 Nov 09).

[45] National Academy of Science, "Alternative Technologies to Replace Antipersonnel Landmines: Executive Summary," p 5.

[46] U.S. Department of the Army, Project Manager Close Combat Systems, Networked Munitions Brochure, http://www.pica.army.mil/pmccs/docs/PMCCS_Brochure_Munitions.pdf , (accessed 06 January 2010).

[47] U.S. Senate, Senator Patrick Leahy, Statement Of Senator Patrick Leahy On The Cartagena Landmine Ban Treaty Review Conference, December 1, 2009, http://leahy.senate.gov/press/200912/120109b.html , (accessed 06 Jan 2010).

[48] Wade Boese, "U.S. did not use Landmines in Iraq War," Arms Control Association – Arms Control Today, July/Aug 2003, http://www.armscontrol.org/act/2003_07-08/landmines_julaug03 , (accessed 6 Jan 10).

[49] Secretary of Defense Robert Gates, Speech at West Point, April 21, 2008, as reported in the Stars and Stripes, 22 April 2008, http://www.stripes.com/article.asp?section=104&article=54260, (accessed 06 Jan 2010).

[50] U.S. Department of the Army, *Explosive Hazards Operations*, FM 3-34.210, p E-17.

[51] Ibid, p F-1.

[52] National Academy of Science, "Alternative Technologies to Replace Antipersonnel Landmines: Executive Summary," p 6.

[53] U.S. Department of the Army, Project Manager Close Combat Systems, Networked Munitions Brochure.

[54] LTC Raymond E. Boyd, Chief, Assured Mobility Branch, MANSCEN, CDID, RDD, email interview by author, 9 November 2009.

[55] U.S. Department of the Army, Project Manager Close Combat Systems, Networked Munitions Brochure.

[56] U.S. Department of the Army, Project Manager Close Combat Systems, Briefing for Precision Strike Association, NDIA Picatinny Chapter, June 2009, http://www.dtic.mil/ndia/2009psa_arm/tuespelino.pdf , (accessed 6 Jan 2010).

[57] U.S. Department of the Army, Project Manager Close Combat Systems, Networked Munitions Brochure.

[58] Paul Kelly, Support Contractor, BRTRC, email interview by author, 4 February 2010.

[59] Author's observations.

[60] Tony Lombardo, "Unattended Ground Sensors being designed, tested," *Army Times*, 2 Sept 2009, http://www.armytimes.com/news/2009/09/army_groundsensor_090109w/ , (accessed 07 Jan 2010).

[61] U.S. Department of the Army, *Combined Arms Obstacle Integration*, FM 90-7, (Washington, DC: U.S. Department of the Army, 10 April 2003), p 2-9.

[62] Adam Baddeley, "U.S. Army Installing $1.5B Worth of Sensor Towers," United States Geospatial Intelligence Foundation, *Geospatial Intelligence Forum*, November/December 2009, http://www.geospatial-intelligence-forum.com/mgt-archives/218-gif-2009-volume-7-issue-6/2333-persistence-imperative.html , (accessed 4 Feb 2010).

[63] LTC Raymond E. Boyd, Chief, Assured Mobility Branch, MANSCEN, CDID, RDD, email interview by author, 5 November 2009.

[64] Paul Kelly, Support Contractor, BRTRC, email interview by author, 4 February 2010.

[65] U.S. Department of the Army, *Explosive Hazards Operations*, FM 3-34.210, p E-17.

[66] Those familiar with the military acquisition process will no doubt raise a note of caution in this regard: Increasing the doctrinal roles or requirements of a developmental piece of equipment risks delaying its fielding as the equipment is then subject to additional testing to ensure it adequately meets the new requirements. This can be mitigated, however, if the requirements are placed against Increment II (a new version with imaging capabilities).